Lessons from the Ashes: Improving Transportation Safety Through Accident Investigation

2019 Westminster Lecture on Transport Safety

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December 4, 2019

Our mission:

Prevent Accidents

Reduce Injuries

Save Lives


CBS THIS MORNING
DEADLY LIMO CRASH
20 KILLED IN ACCIDENT IN UPSTATE NY


231909
R


CONCEPTION

NTSB

Bruce Landsberg

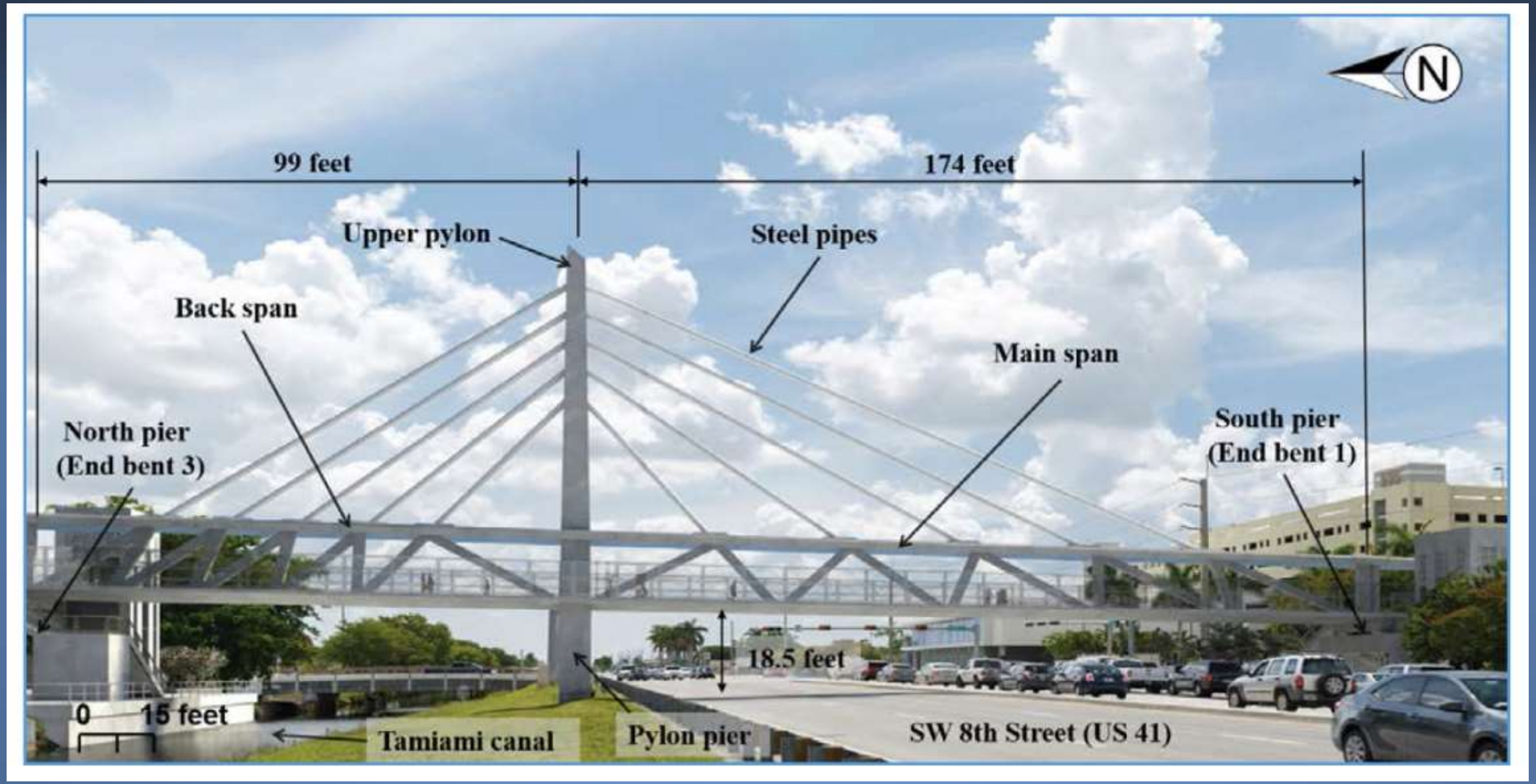
Robert Sumwalt

Jennifer Homendy

NTSB

NTSB Response Operations Center

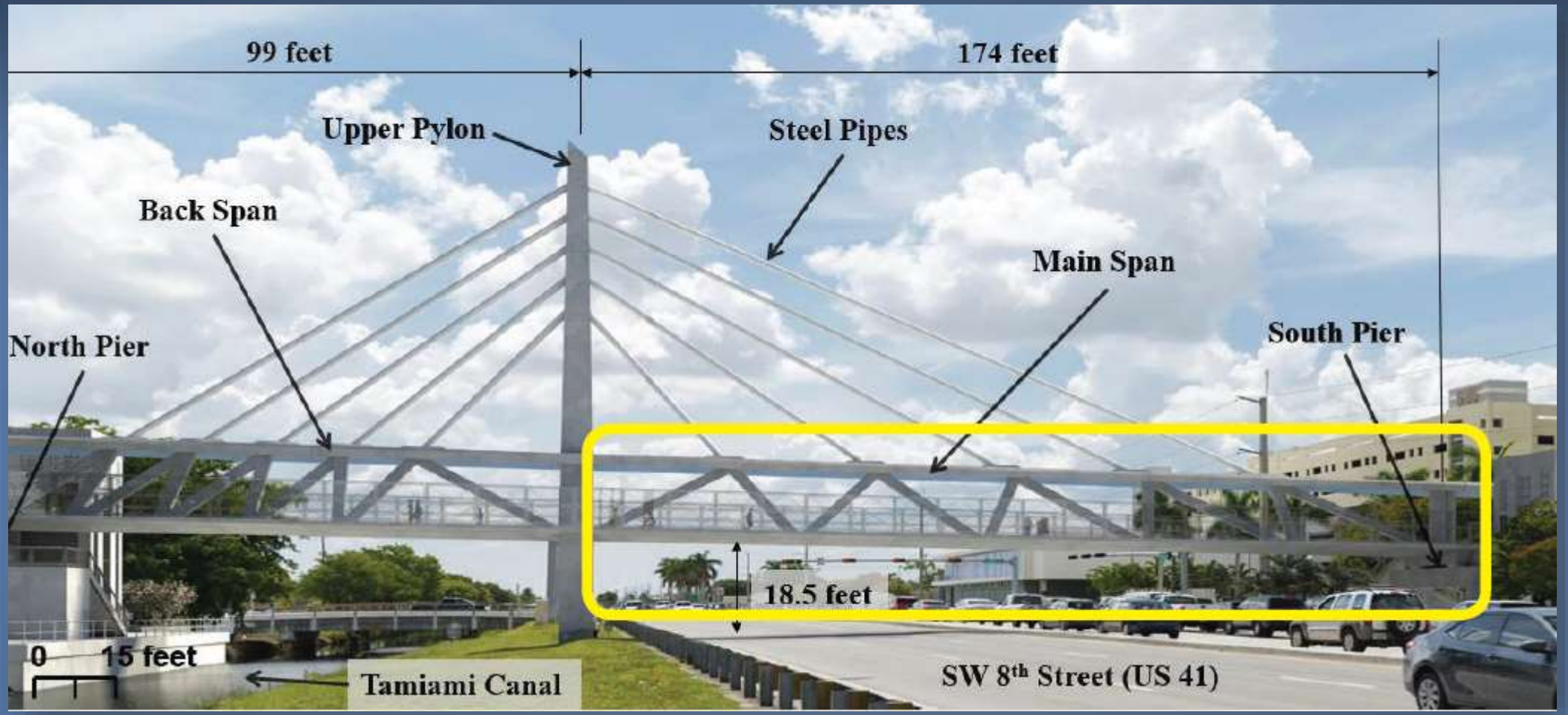

NTSB
NTSB
United States Of America



Miami, Florida. March 15, 2018

NTSB


Canopy
Diagonal Supports
Walkway

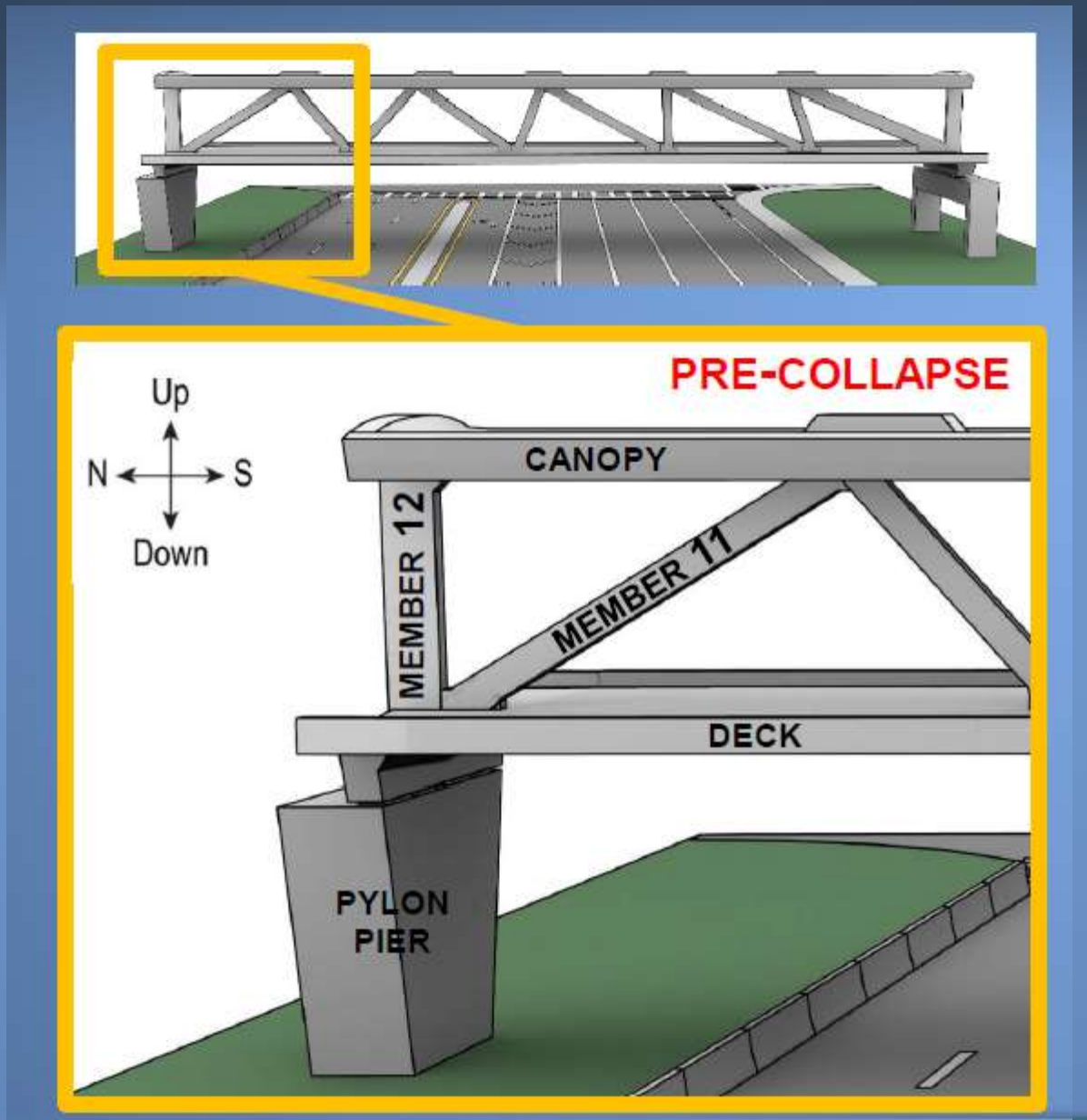

99 feet
174 feet
Upper Pylon
Steel Pipes
Back Span
Main Span
North Pier
South Pier
18.5 feet
0
15 feet
Tamiami Canal
SW 8th Street (US 41)

NTSB


Miar
3:53 PM
WFOR
BREAKING NEWS
POLICE: SEVERAL FATALITIES IN BRIDGE COLLAPSE AT COLLEGE IN MIAMI
Several cars trapped under pedestrian bridge at Florida International Univ
MIX-UP COMES AFTER A FRENCH BULLDOG DIED MONDAY ON A UNITED FL
LIVE
CNN
DOW ▲ 122.77
NEWSROOM

Facing East

NTSB

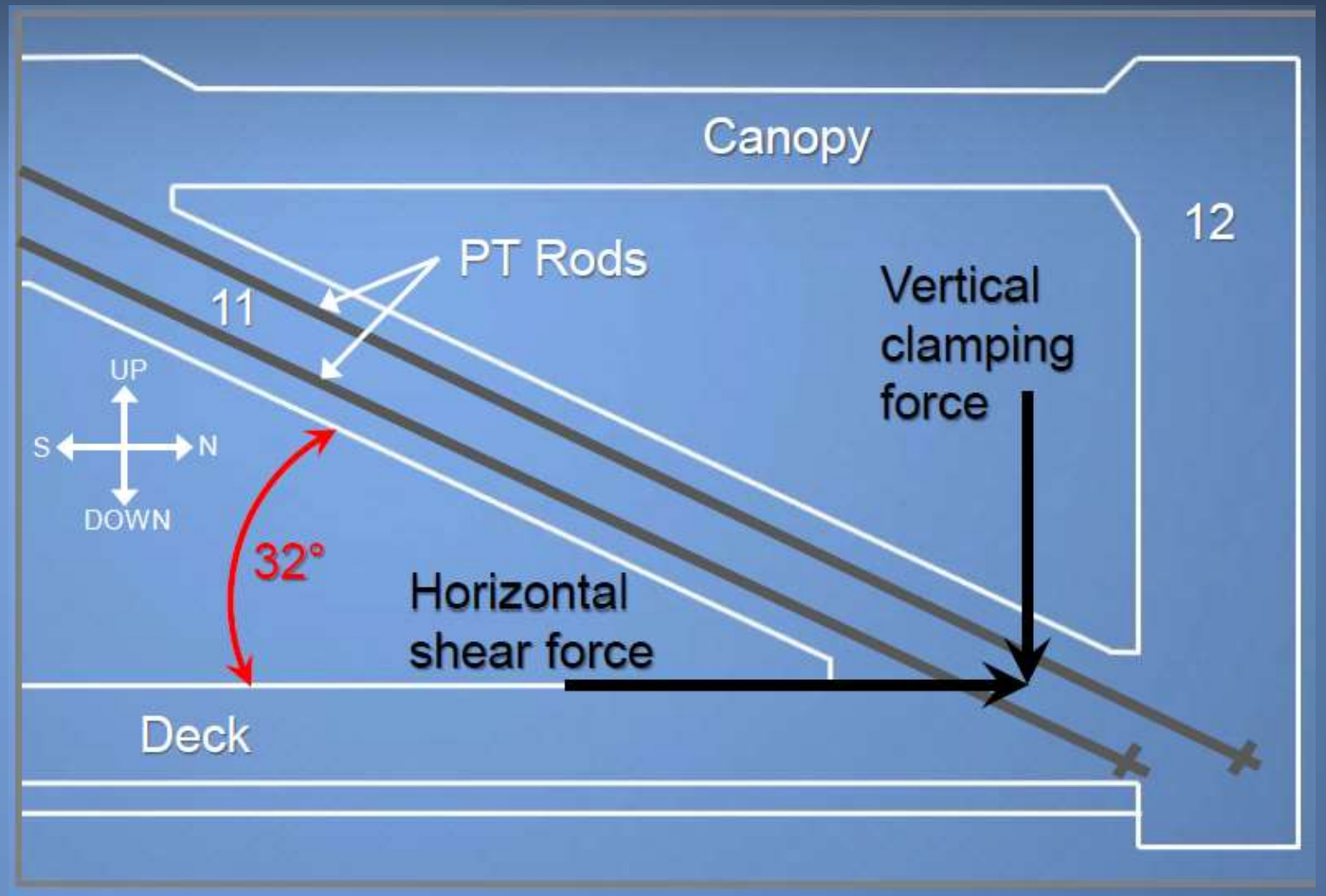

PRE-COLLAPSE
Up
N
S
Down
CANOPY
MEMBER 12
MEMBER 11
DECK
PYLON
PIER

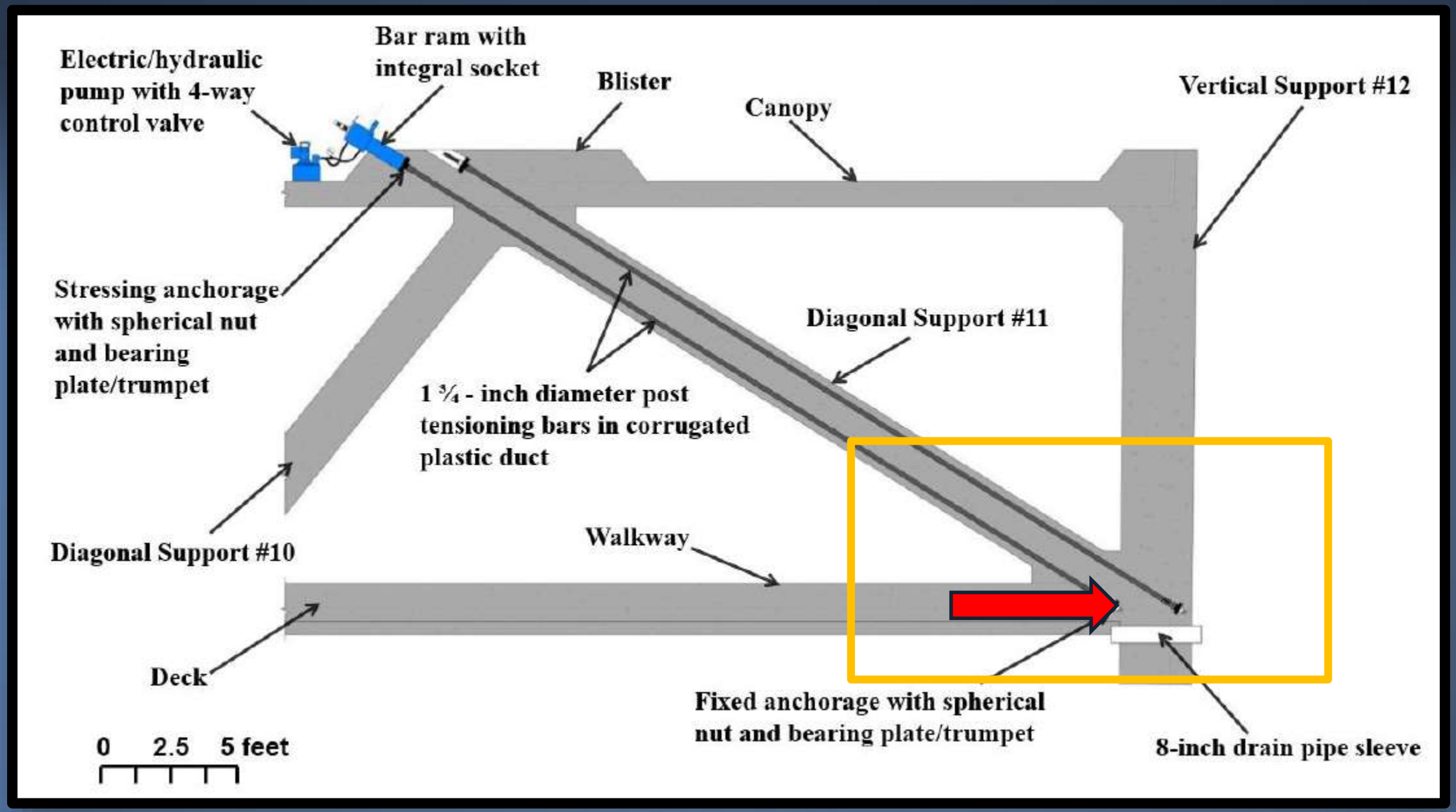
Facing East

Magnitude of horizonal force –

60 percent larger than vertical force

Facing West




Electric/hydraulic pump with 4-way control valve
Bar ram with integral socket
Blister
Canopy
Vertical Support #12
Stressing anchorage with spherical nut and bearing plate/trumpet
Diagonal Support #11
1 ¾ - inch diameter post tensioning bars in corrugated plastic duct
Diagonal Support #10
Walkway
Deck
Fixed anchorage with spherical nut and bearing plate/trumpet
8-inch drain pipe sleeve
0 2.5 5 feet

Facing West

NTSB

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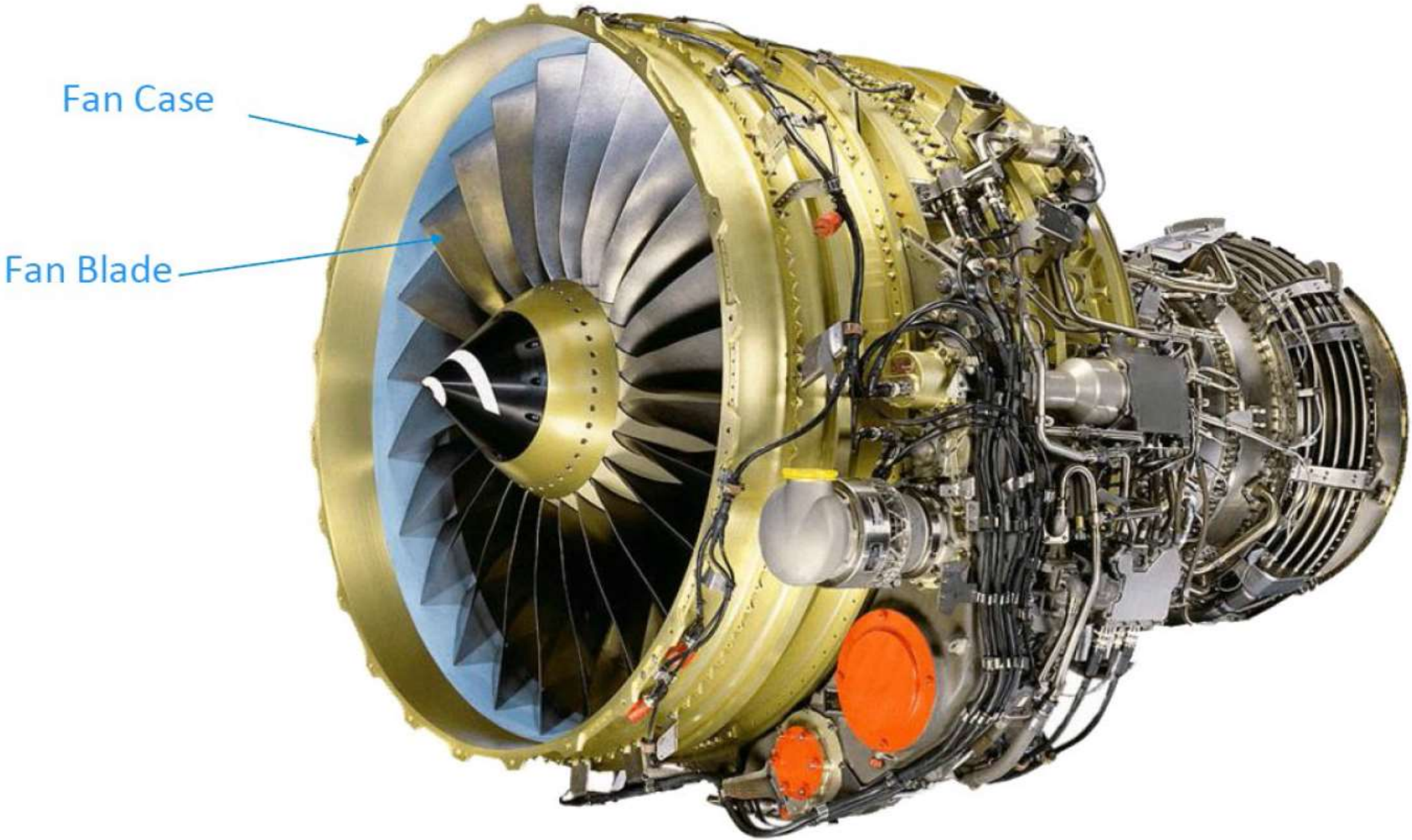
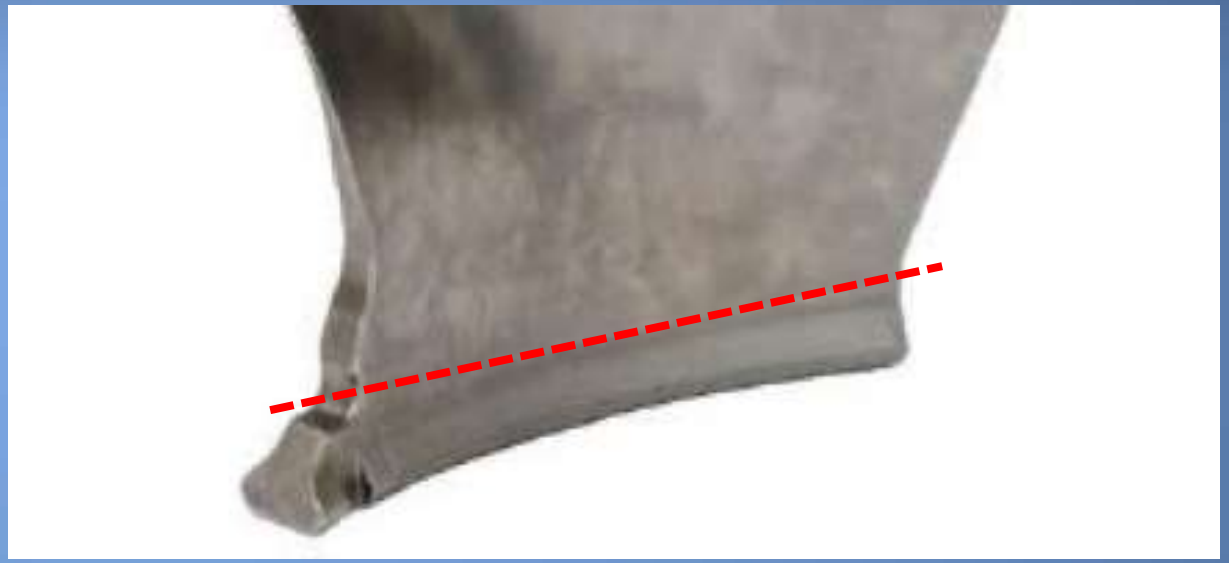
Critical Errors

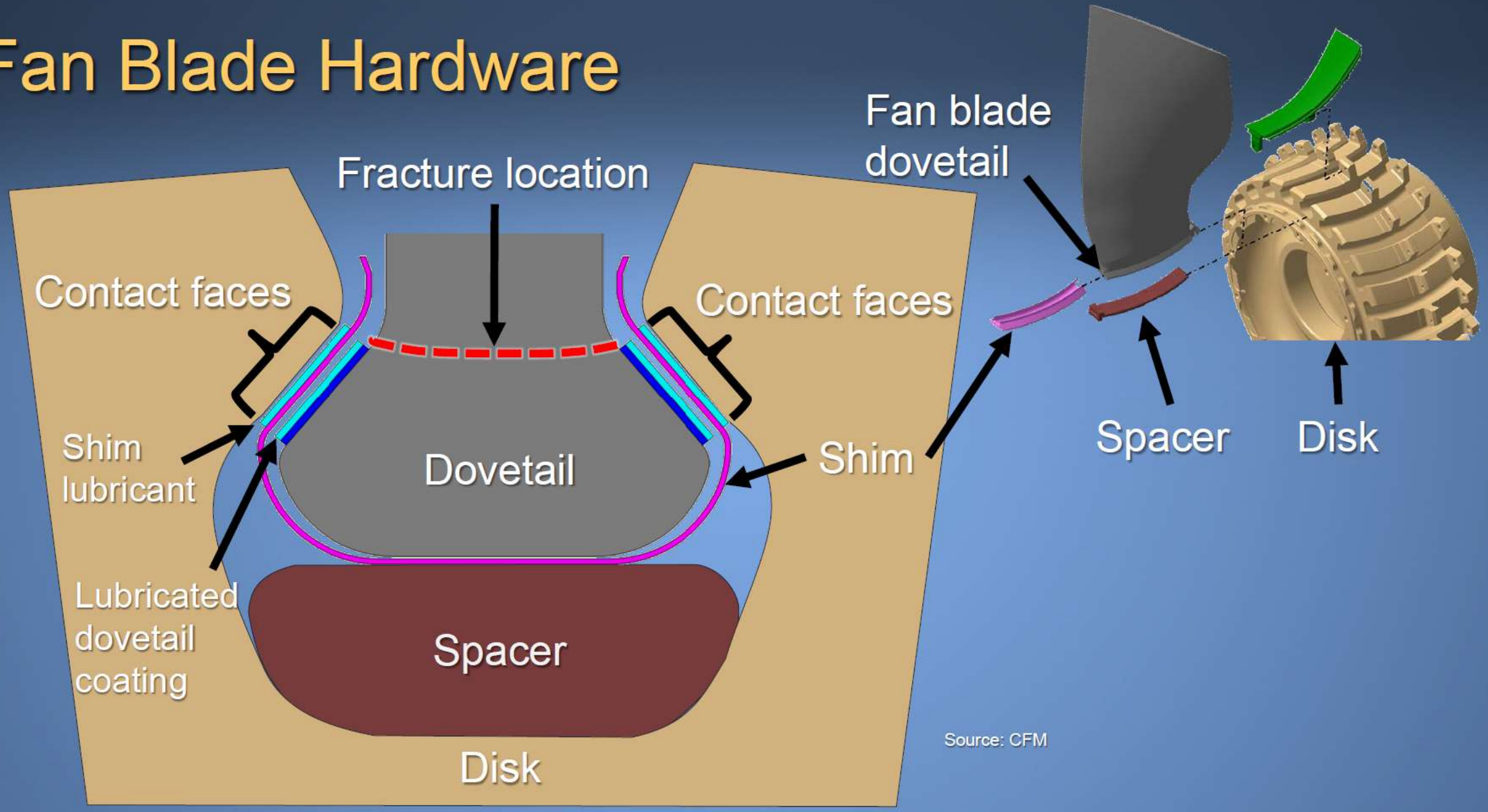
- Bridge was under-designed
- Peer review was insufficient
- Failure to close bridge to traffic and workers

Southwest Airlines 1380
April 17, 2018

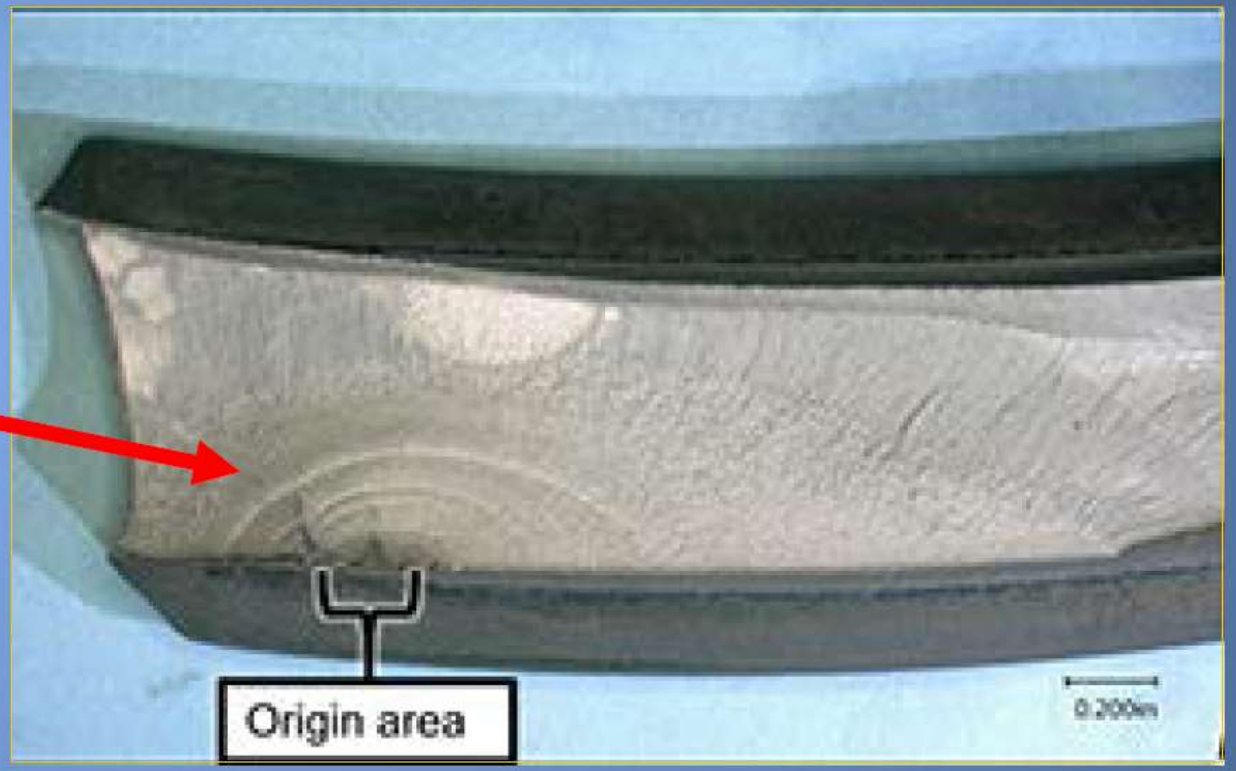

Fan Case
Fan Blade

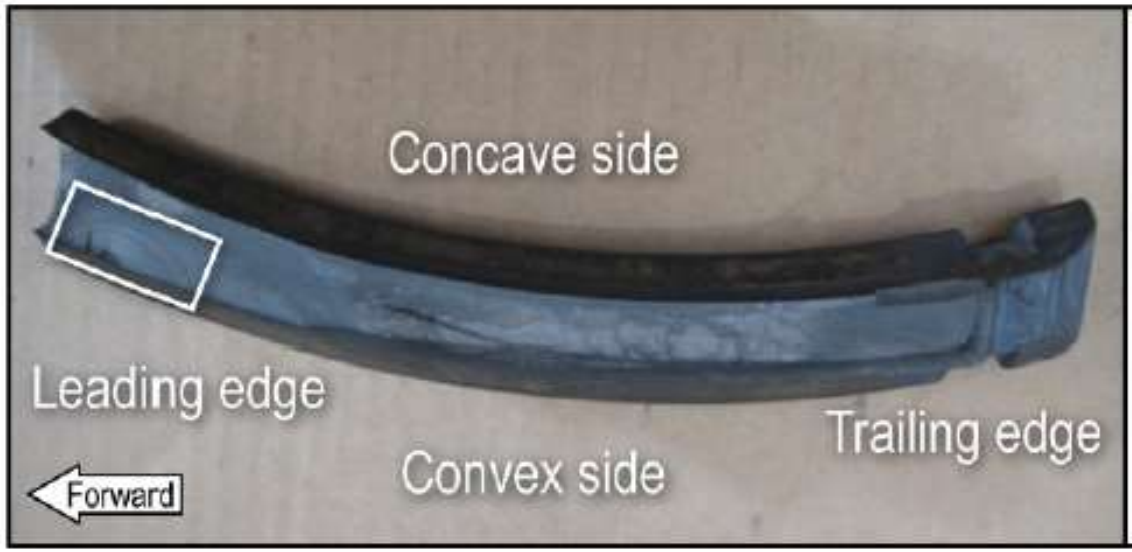


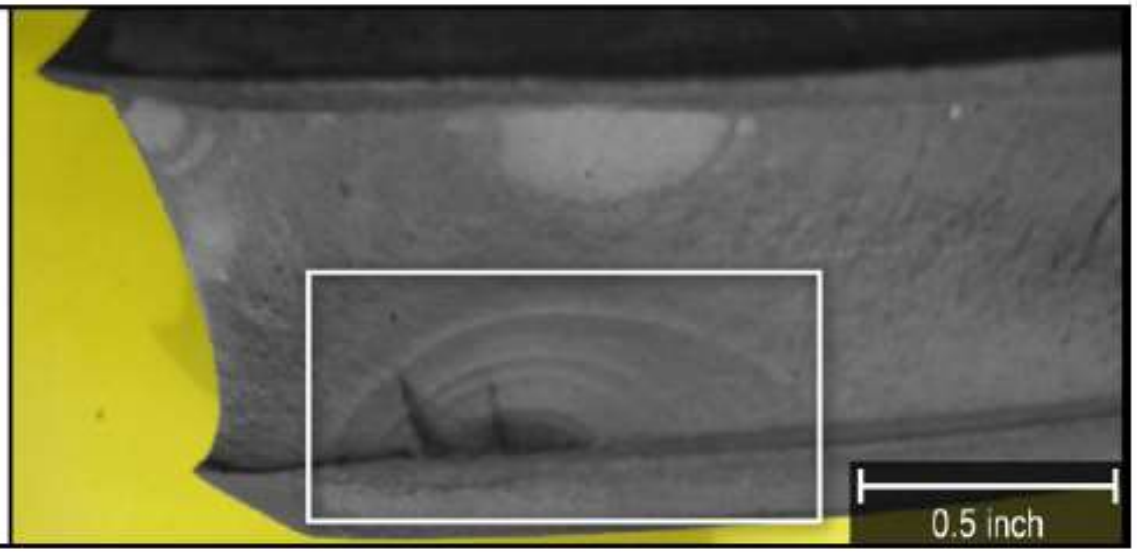
Fan Blade Hardware

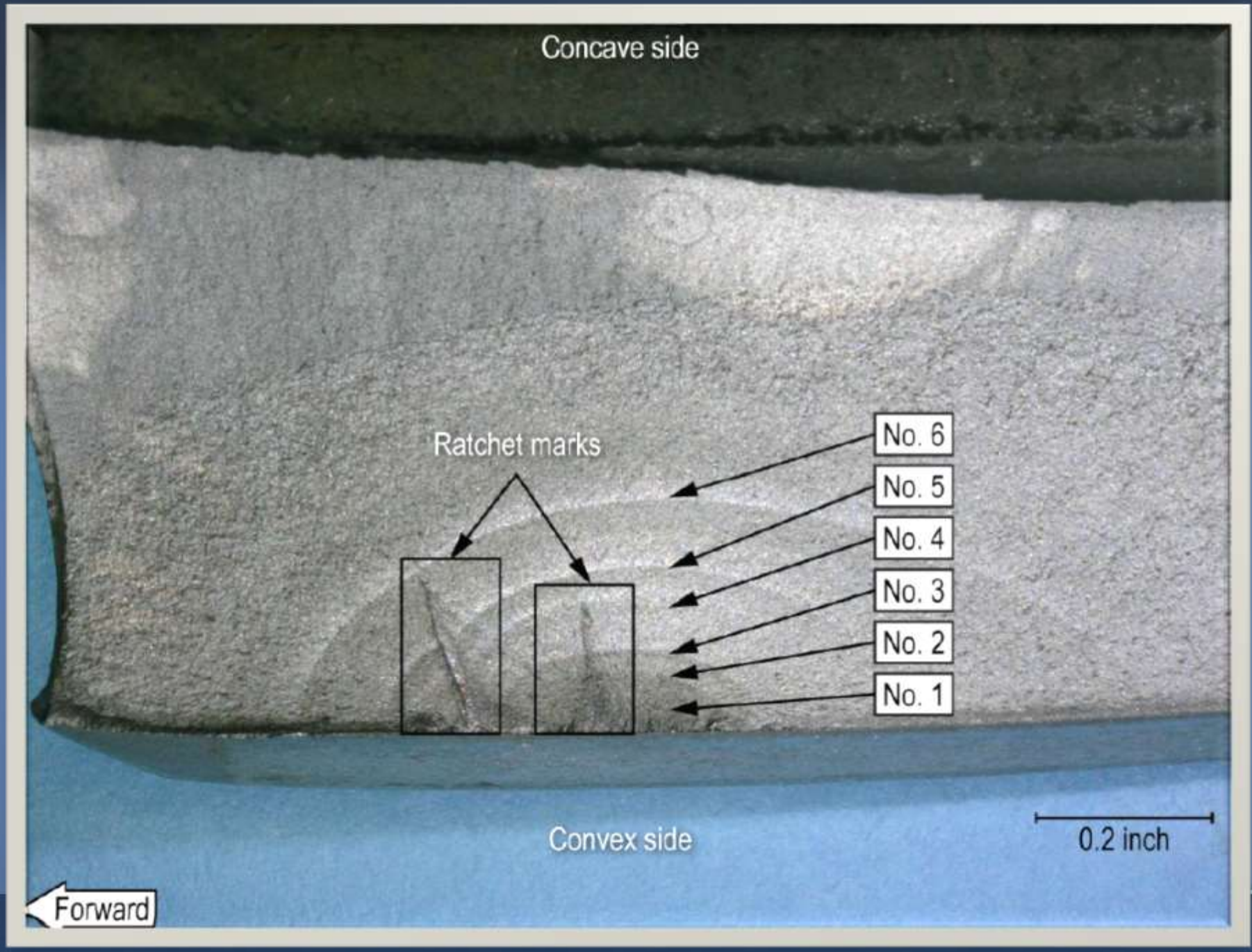


Source: CFM

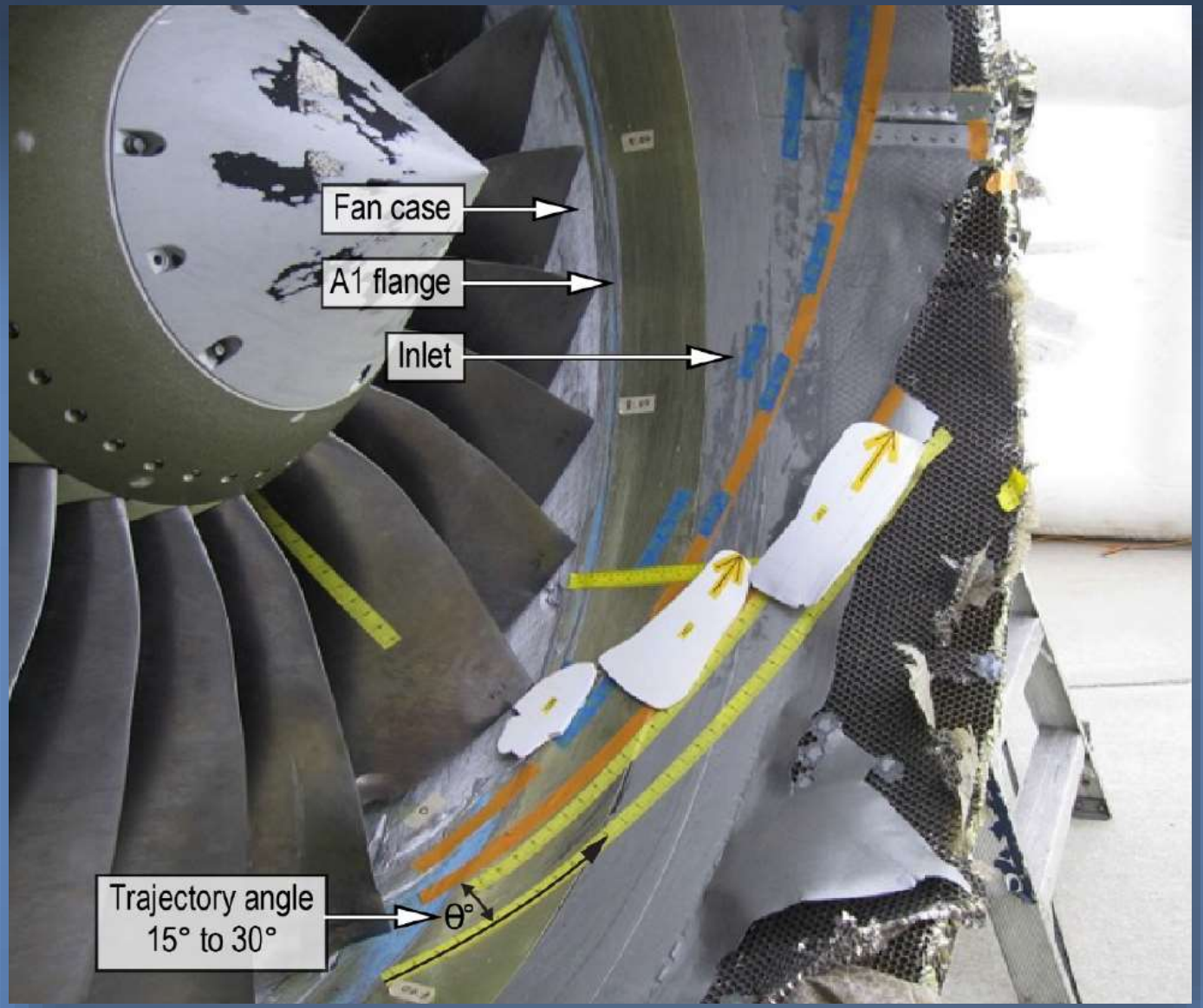

Origin area


Concave side
Leading edge
Trailing edge
Convex side
Forward


0.5 inch

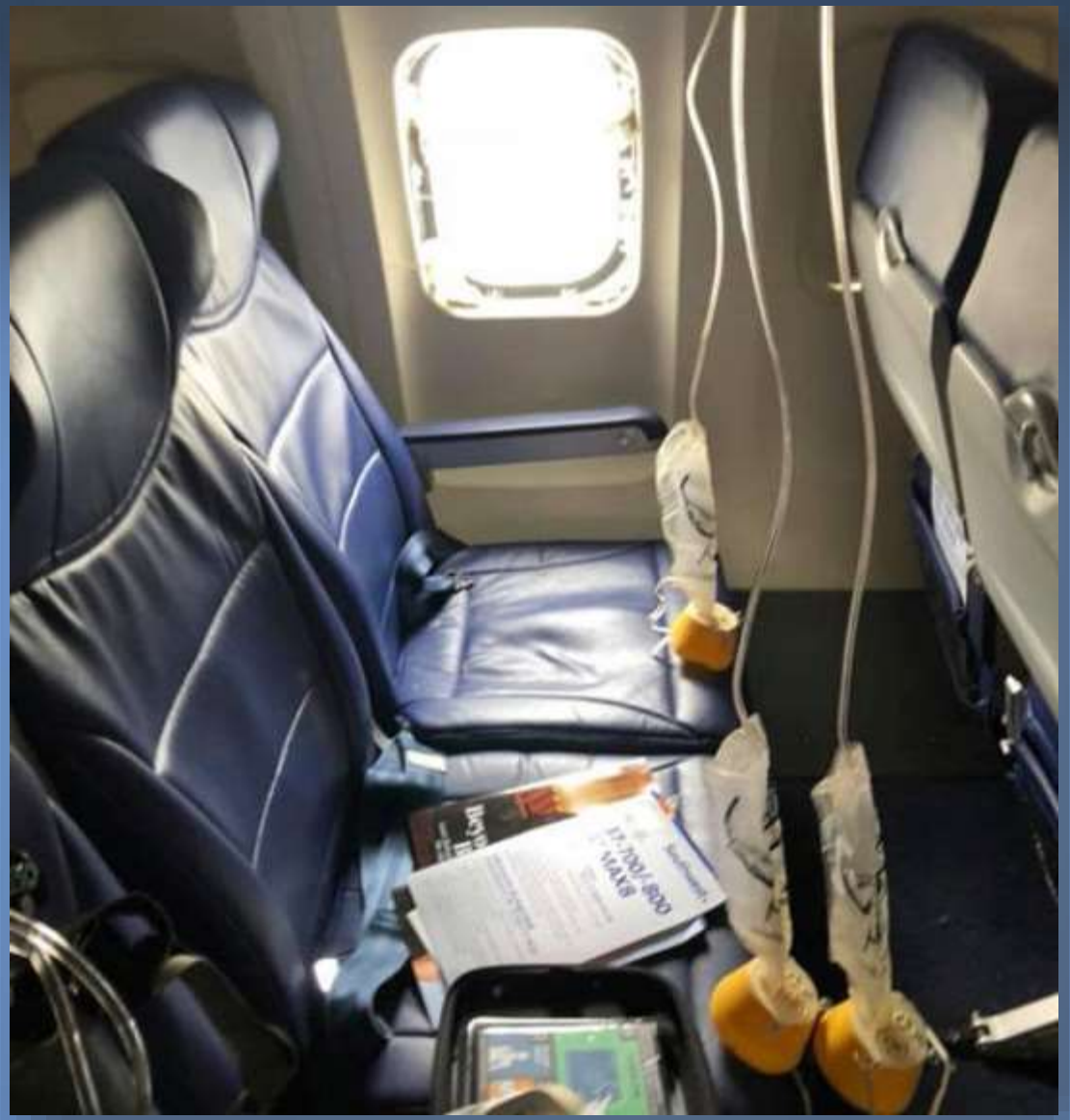

Concave side
Ratchet marks
No. 6
No. 5
No. 4
No. 3
No. 2
No. 1
Convex side
0.2 inch
Forward

NTSB

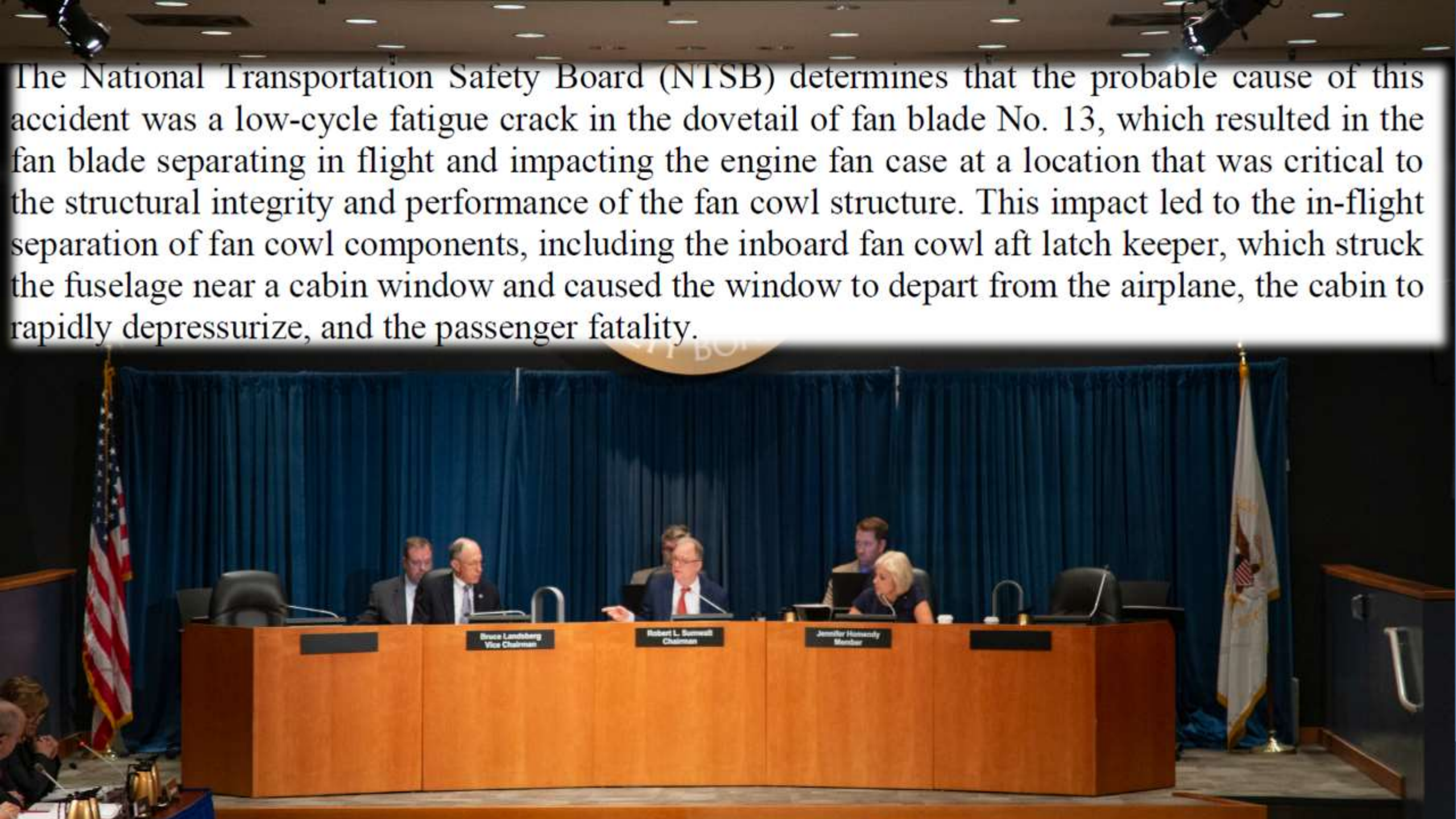

Fan case
A1 flange
Inlet
Trajectory angle
15° to 30°
θ°


Window by seat 14A


Lower aft corner of
inboard fan cowl
Up
Aft


B737-700/-800
QRH

The National Transportation Safety Board (NTSB) determines that the probable cause of this accident was a low-cycle fatigue crack in the dovetail of fan blade No. 13, which resulted in the fan blade separating in flight and impacting the engine fan case at a location that was critical to the structural integrity and performance of the fan cowl structure. This impact led to the in-flight separation of fan cowl components, including the inboard fan cowl aft latch keeper, which struck the fuselage near a cabin window and caused the window to depart from the airplane, the cabin to rapidly depressurize, and the passenger fatality.



Tempe, Arizona
March 18, 2018


Vancouver
Regina
Winnipeg
Seattle
WASHINGTON
NORTH DAKOTA
MONTANA
MINNESOTA
Portland
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
WISCONSIN
MICHIGAN
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
United States
San Francisco
San Jose
CALIFORNIA
Las Vegas
Los Angeles
ARIZONA
NEW MEXICO
San Diego
Phoenix
Tucson
El Paso
BAJA CALIFORNIA
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEON
Monterrey
Gulf of California
Kansas City
OKLAHOMA
TEXAS
Dallas
Austin
Houston
San Antonio
Gulf of Mexico
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
Nashville
ARKANSAS
MISSISSIPPI
LOUISIANA
New Orleans
Indianapolis
Chicago
Detroit
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Montreal
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NEW HAMPSHIRE
MASSACHUSETTS
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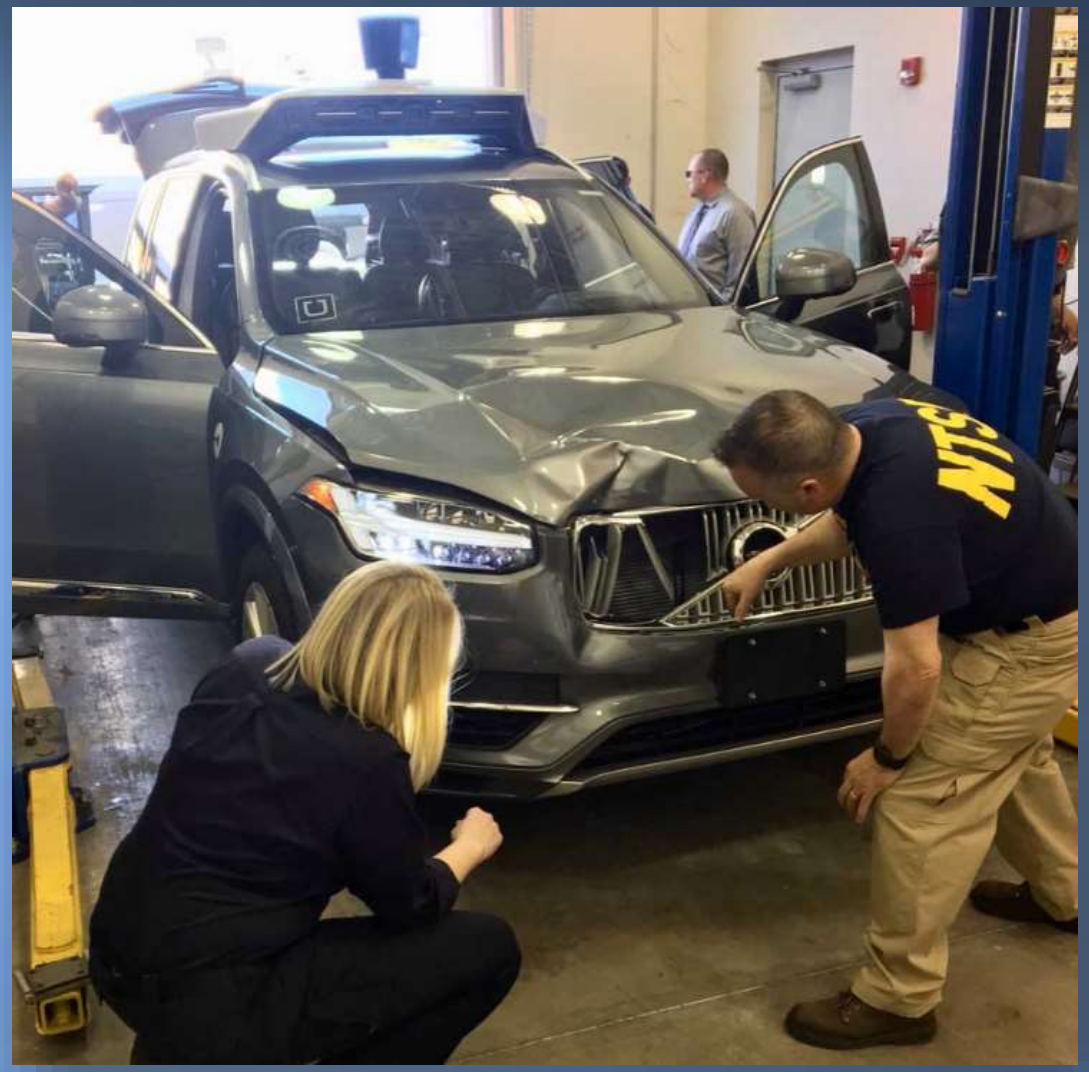
PENNSYLVANIA
NJ
DE
Washington
VIRGINIA
NORTH CAROLINA
Charlotte
SOUTH CAROLINA
Atlanta
GEORGIA
Jacksonville
FLORIDA
Orlando
Miami
The Bahamas
Turks and Caicos Islands
Havana
Cuba
Haiti
Bermu

Crash Overview

- Sunday, March 18, 2018
- 9:58 p.m.
- Tempe, Arizona
- North Mill Avenue
- Automated test vehicle
- Night, dry, illuminated roadway
- 1 fatality, pedestrian

Crash Overview

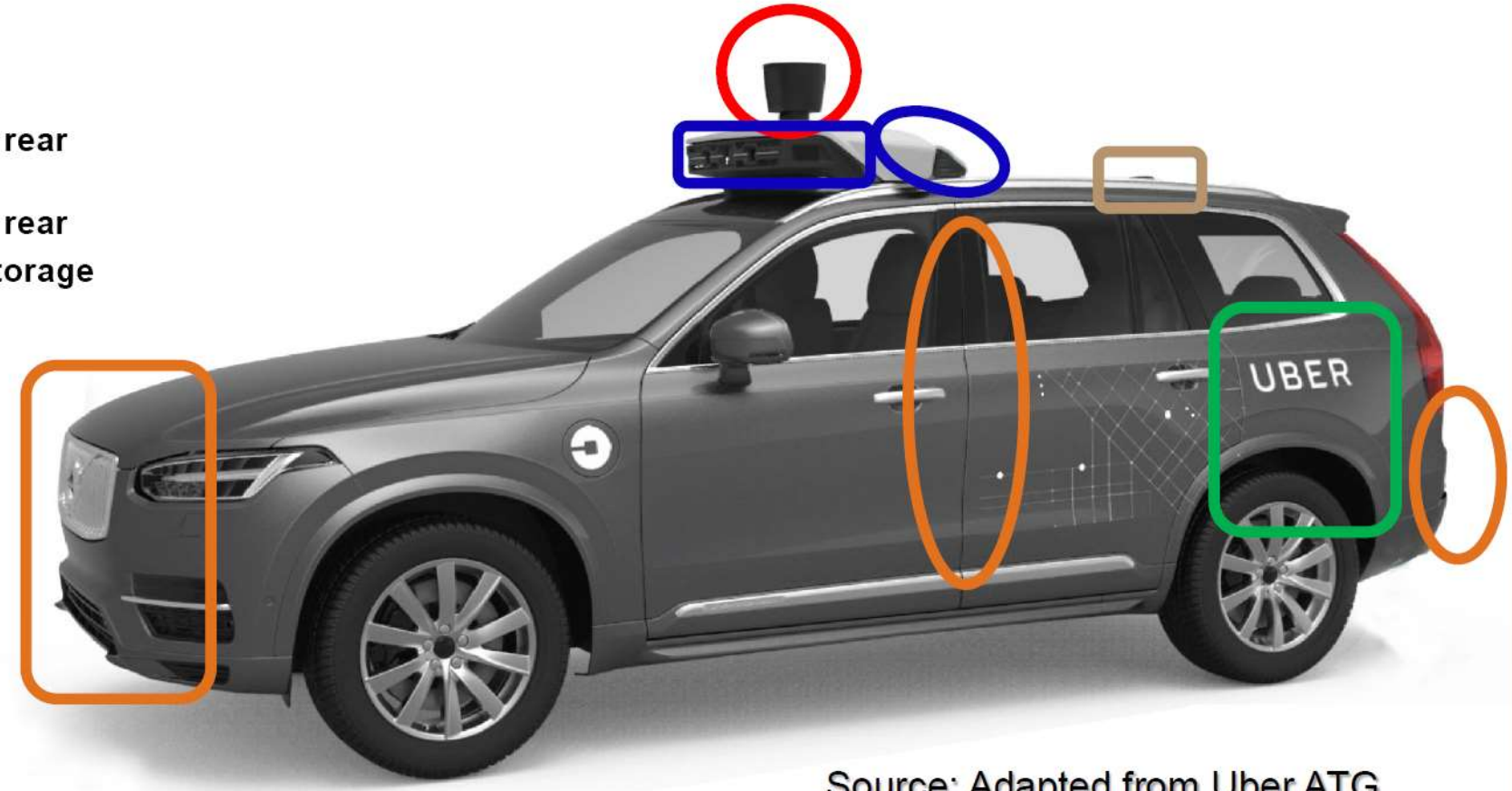
- Test vehicle based on modified 2017 Volvo XC90
- Uber ATG developmental automated driving system (ADS)
- Female operator occupied driver's seat
- Test vehicle was under ADS control



Test Vehicle: ADS Sensors

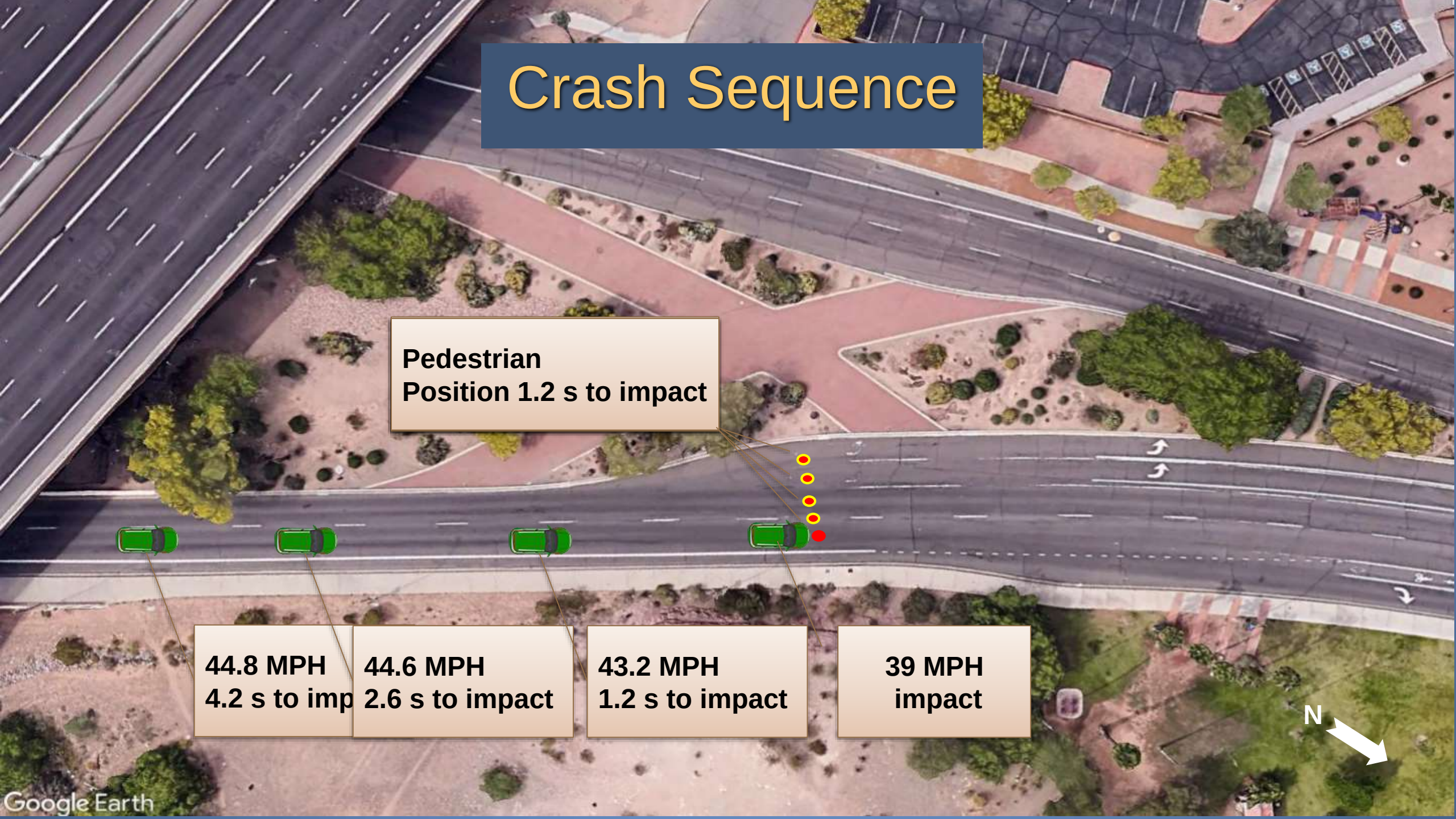
Systems

- Lidar
- Camera
  - Forward
  - Side and rear
- Radar
  - Forward
  - Side and rear
- ADS computing and data storage
- Telecommunication (GPS)



Source: Adapted from Uber ATG

Crash Sequence

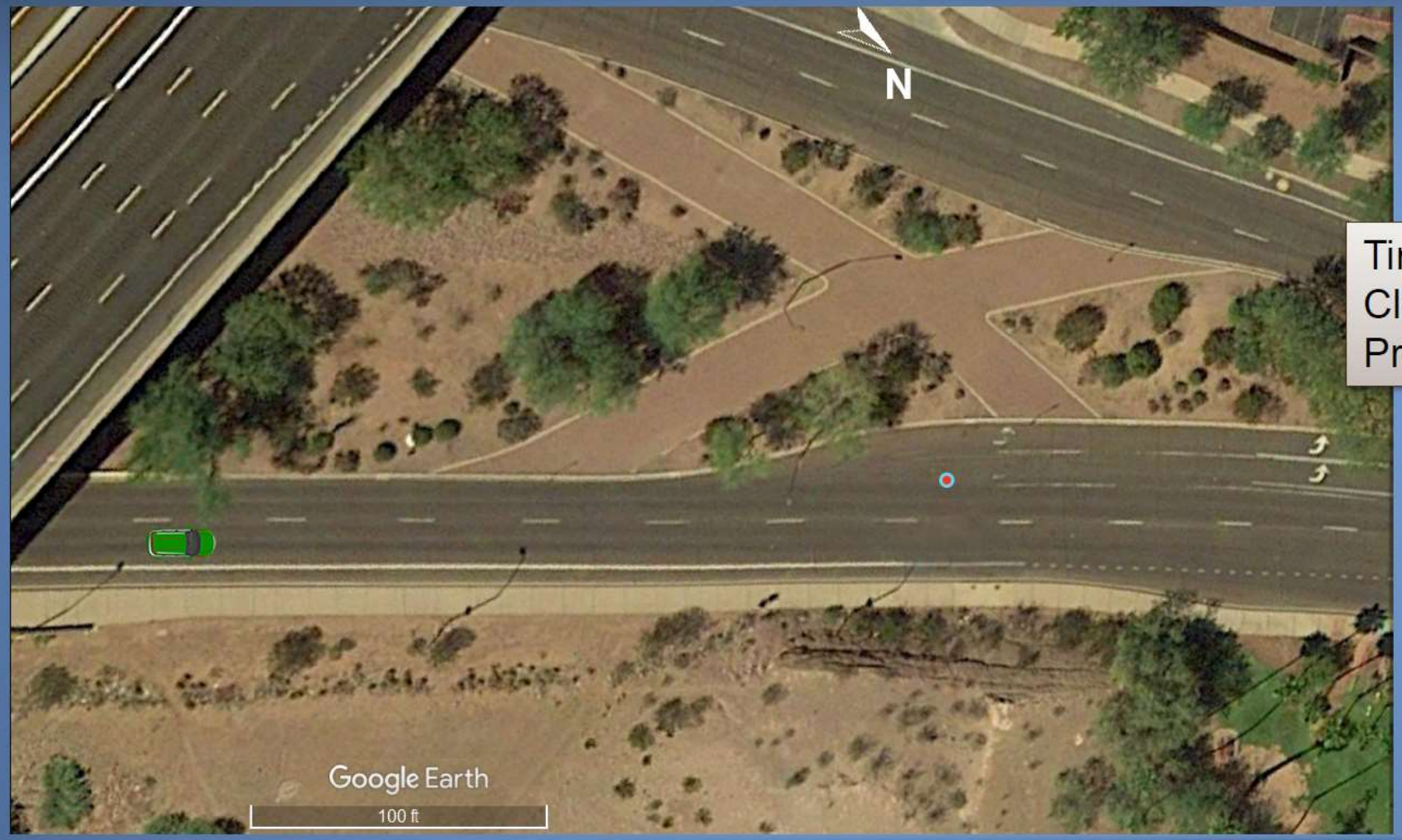


Perception and Motion During the Crash

Time to crash: 5.6 seconds
Classification: Vehicle
Predicted path: None

NTSB

Perception and Motion During the Crash



Time to crash: 3.9 seconds
Classification: Vehicle
Predicted path: Left lane

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Perception and Motion During the Crash

Time to crash:	2.6 seconds
Classification:	Bicycle
Predicted path:	Static

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Perception and Motion During the Crash

Time to crash: 1.5 seconds
Classification: Other
Predicted path: Static, partially on vehicle's path

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Perception and Motion During the Crash

Time to crash: 1.2 seconds
Classification: Bicycle
Predicted path: Fully on path of the vehicle
Braking suppression begins

Perception and Motion During the Crash

Time to crash: 0.2 seconds
Classification: Bicycle
Predicted path: Fully on path of the vehicle
Braking suppression ends

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Perception and Motion During the Crash

- Vehicle operator initiated steering 20 msec before impact

NTSB

The National Transportation Safety Board determines that the probable cause of the crash in Tempe, Arizona, was the failure of the vehicle operator to monitor the driving environment and the operation of the automated driving system because she was visually distracted throughout the trip by her personal cell phone. Contributing to the crash were the Uber Advanced Technologies Group's (1) inadequate safety risk assessment procedures, (2) ineffective oversight of vehicle operators, and (3) lack of adequate mechanisms for addressing operators' automation complacency—all a consequence of its inadequate safety culture. Further factors contributing to the crash were (1) the impaired pedestrian's crossing of N. Mill Avenue outside a crosswalk, and (2) the Arizona Department of Transportation's insufficient oversight of automated vehicle testing.

Pedestrian Safety

National Transportation Safety Board

Selective Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee

Special Inves

National Transportation Safety Board

Reducing Speeding-Related Crashes Involving Passenger Vehicles

Safety Study

NTSB/SS-17/01
PB2017-102341

National Transportation Safety Board

NTSB

Vulnerable Road Users

Countermeasures

- Vehicle-based
- Infrastructure planning for pedestrian safety
- Improved pedestrian safety data

Vehicle-based countermeasures

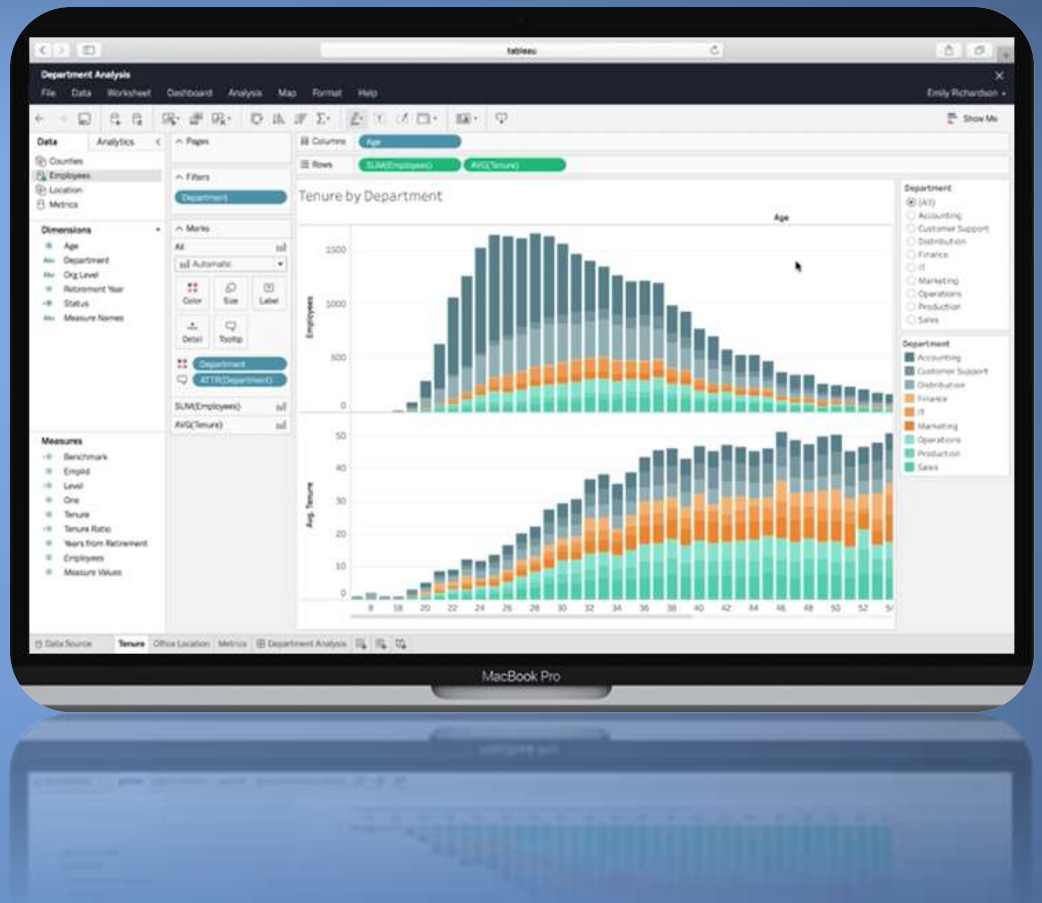
- Vehicle physical designs
- Vehicle headlight performance
- Collision avoidance technologies

Infrastructure planning for pedestrian safety

- Pedestrian safety action plans
- Design guides
- Expanding local site-specific planning activities

Improved pedestrian safety data

- Pedestrian exposure data
- Crash data for system development and research
- Improved aggregated event data



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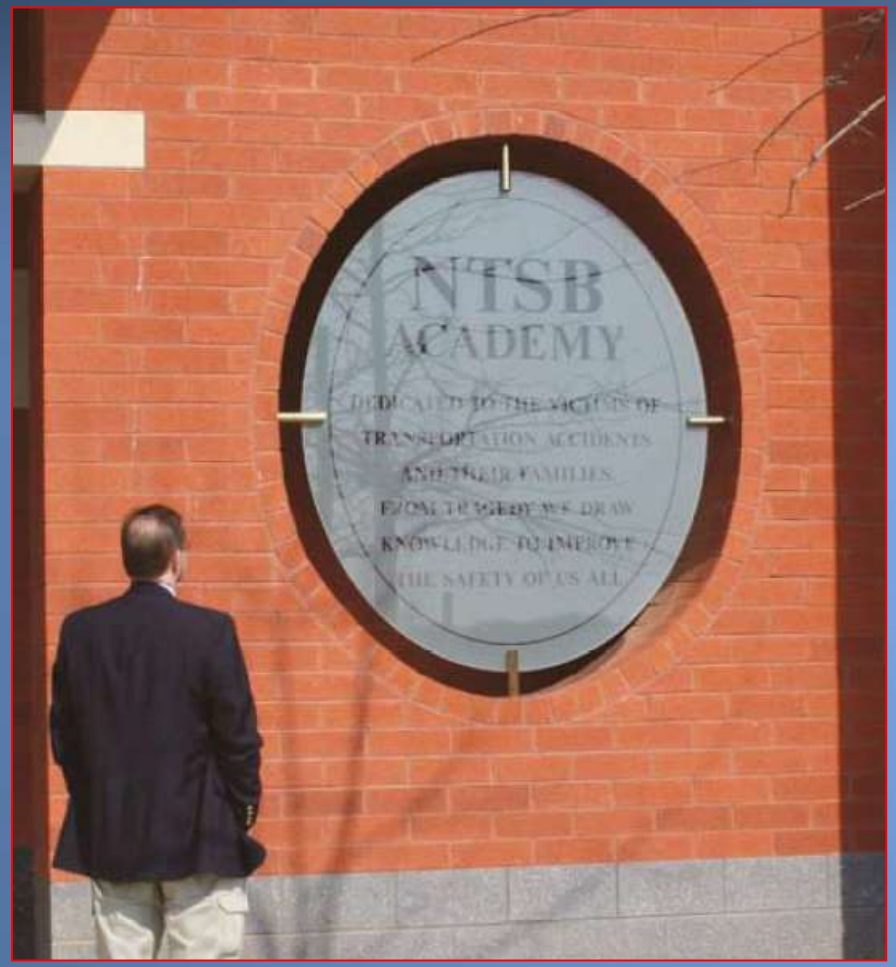

"From tragedy we draw knowledge to improve the safety of us all."

National Transportation Safety Board